

SURFACE EXCESS OF CLAY COLLOIDS AT GAS-WATER INTERFACES

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OBJECTIVES

Colloids have been found to favorably sorb at air-water interfaces in many natural environments. In vadose zones, sorption of colloid-associated contaminants at air-water interfaces can influence contaminant fate and transport. For solutions containing surface-active molecules, measurement of changes in surface tension with changes in solute concentration permits calculation of their surface excess through the Gibbs adsorption equation. For suspensions of particles, surface tension changes are often not measurable. Much effort has been devoted to characterizing surface accumulations of particles and associated species. Because of large uncertainties in thicknesses and interfacial areas sampled, results are often reported as the enrichment factors for a given estimated thickness. Our objectives were to develop a method for quantifying colloid surface excesses at air-water interfaces without requiring assumptions concerning the thickness of interfacial regions (completed in 1998), and to obtain the first partition coefficient data of most common subsurface colloids.

APPROACH

The bubble column method (Wan and Tokunaga, 1998) was used to measuring partition coefficients of different types of clay (kolinite, montmorillonite and illite, and goethite colloids at the gas-water interface. In the bubble column, air is bubbled through a vertical column containing the dilute colloidal suspension, with an open free surface at the top. The rising bubbles sorb and carry the surface-active species upwards, then release them back to the solution at the free surface where the bubbles burst. At steady-state, a concentration profile is established along the column length, which reflects the balance between upward transport by partitioning onto rising bubbles and downward transport by eddy dispersion. By predetermining the column eddy dispersion coefficient for given conditions (column dimensions, air flow rate and bubble size) and measuring the steady-state concentration profile, the partitioning between bulk and surface regions can be determined.

ACCOMPLISHMENTS

Using our bubble column method, we measured the partition coefficients (K) of many common types of subsurface colloids under environmentally relevant conditions. Montmorillonite is essentially non-surface active at any given pH and ionic strength. Illite was slightly surface active, with increased K values at lower pH and higher ionic strength ($K=0$ to $40 \mu\text{m}$). Kaolinite particles are very highly surface active at pH below 7 (K values are up to $240 \mu\text{m}$). Humic acid is slightly to moderately surface active. Goethite is extremely surface active at pH below 9 (K values up to $320 \mu\text{m}$). This method permits quantification of surface excesses of a wide range of inorganic, organic and microbial colloids, as well as molecular species complexed onto colloids. Through the measured K values, we are now able to predict what types of colloids are surface active, to what degree and under what conditions.

SIGNIFICANCE OF FINDINGS

The ability to measure colloid surface excesses at air-water interfaces enables more quantitative analyses of a variety of environmental processes. This is especially relevant in the vadose zone, where there can be high val-

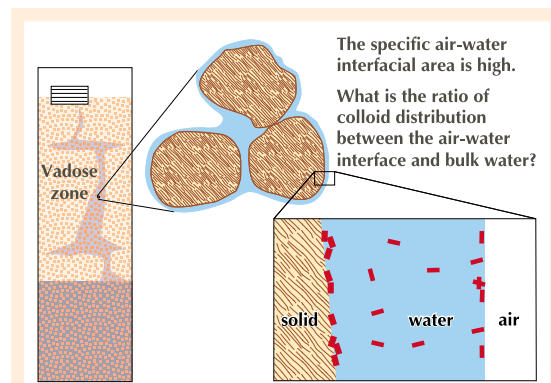


Figure 1. Vadose zone implications of colloid sorption at air-water interfaces. Depending on water film thickness and flow, colloid partitioning at air-water interfaces may enhance or retard their transport through the vadose zone.

ues of air-water interfacial area per unit bulk volume. Due to the common existence of thin water films in the vadose zone, the distribution of surface-active colloids between bulk water and the air-water interface can become significant. The calculated values of colloid distribution at the air-water interface relative to bulk water ranged from about 1 to 20 for a wide range of the soil saturation, for most types of colloids studied. This has important implications on colloid transport and transformation in vadose environments.

RELATED PUBLICATIONS

- Wan, J., and T.K. Tokunaga, Measuring partition coefficients of colloids at air-water interfaces, *Environ. Sci. Technol.*, 32, 3293-3298, 1998.
- Wan, J., and T.K. Tokunaga, Surface excess of clay colloids at gas-water interfaces, *J. Colloid and Interface Science*, submitted.

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